MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2018

January–March 2018—Volume 133, pp. 23–29
https://doi.org/10.5248/133.23

Notes on rust fungi in China 4. Hosts and distribution of *Hyalopsora aspidiotus* and *H. hakodatensis*

Jing-Xin Ji[1], Zhuang Li[2], Yu Li[1],
Jian-Yun Zhuang[3], Makoto Kakishima[1, 4*]

[1] *Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, Changchun, Jilin 130118, China*
[2] *College of Plant Pathology, Shandong Agricultural University, Tai'an 271000, China*
[3] *Institute of Microbiology, Chinese Academy of Sciences, Beijing 10001, China*
[4] *University of Tsukuba, Tsukuba, Ibaraki 305-8572, Japan*

* Correspondence to: *kakishima.makoto.ga@u.tsukuba.ac.jp*

Abstract—Hosts and distribution in China of two fern rust fungi, *Hyalopsora aspidiotus* and *H. hakodatensis*, are clarified based on new collections and examination of herbarium specimens. The ferns *Athyrium iseanum*, *Deparia orientalis*, and *Phegopteris connectilis* are newly identified hosts for *H. hakodatensis*, while *Gymnocarpium jessoense* represents a new host for *H. aspidiotus* in China. The rusts are also reported as new for several Chinese provinces.

Key words—*Pucciniomycetes*, taxonomy, *Uredinales*

Introduction

Rust fungi on ferns—species of *Hyalopsora*, *Milesina*, and *Uredinopsis* (together with anamorphic taxa designated as *Milesia*)—are distributed mainly in temperate to cold areas, especially where their alternate hosts (*Abies* species) are found (Cummins & Hiratsuka 2003). Many fern rust species are believed to occur in China because of the wide range of areas suitable for their growth. However, these rust fungi have been insufficiently investigated on the mainland. Tai (1979), who listed two *Hyalopsora*, six *Milesina*, and eight *Uredinopsis* species, recorded most of the sixteen species from Taiwan.

Hyalopsora is distinguished from the other two genera primarily by the hyaline walls and pigmented cytoplasm of its urediniospores and the predominant production of amphispores (Cummins & Hiratsuka 2003). During an investigation of rust fungi in Jilin Province, northeast China, *Hyalopsora* species were found on two species of ferns growing in coniferous forests (*Abies nephrolepis*). These ferns have not been previously recorded as host plants of *Hyalopsora* species in China. After morphological comparisons with specimens borrowed from Fungarium, Institute of Microbiology Chinese Academy of Sciences (HMAS), the rusts were identified as *H. aspidiotus* and *H. hakodatensis*. Their host plants and distribution in China were also clarified based on fungarium specimens.

Materials & methods

The uredinial stages of rusts on two ferns, *Gymnocarpium jessoense* and *Deparia orientalis,* collected on Changbai Mt., Yanji City, Jilin Province, China. After morphological examination, the specimens were deposited in the Herbarium of Mycology, Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, Changchun, China (HMJAU). *Hyalopsora* specimens were also borrowed for morphological comparisons from the Fungarium, Institute of Microbiology Chinese Academy of Sciences, Beijing, China (HMAS).

Morphological characters, including the size and shape of sori and spores, were examined using light microscopy (LM). Spores or thin-sections of sori were mounted in a drop of lactophenol solution on glass slides and examined and photographed using Zeiss AXIO imager equipped with differential interference contrast (DIC). Approximately 30 spores were randomly chosen from each specimen and the length, width, and wall thickness of spores were measured using Leica LAS X software attached to a Leica DM2000 microscope.

The surface features of spores were examined by scanning electron microscopy (SEM). For SEM, sori and spores obtained from dry specimens were attached to specimen holders by double-sided adhesive tape and coated with platinum-palladium using a Hitachi MC1000 Ion Sputter Coater and examined with a Hitachi SU8010 FE-SEM operated at 5–7 kV.

Results & discussion

Following morphological observations, the Jilin Province specimens were identified as *Hyalopsora aspidiotus* and *H. hakodatensis*. The following descriptions are based on Chinese specimens.

Hyalopsora aspidiotus (Peck) Magnus, Ber. Deutsch. Bot. Ges. 19: 582, 1901. Fig. 1

Spermogonial and aecial stages not found. Uredinia amphigenous but mostly hypophyllous, minute, subepidermal, at first covered by the epidermis and then erumpent, yellow to golden-yellow. Urediniospores oblong or ellipsoid,

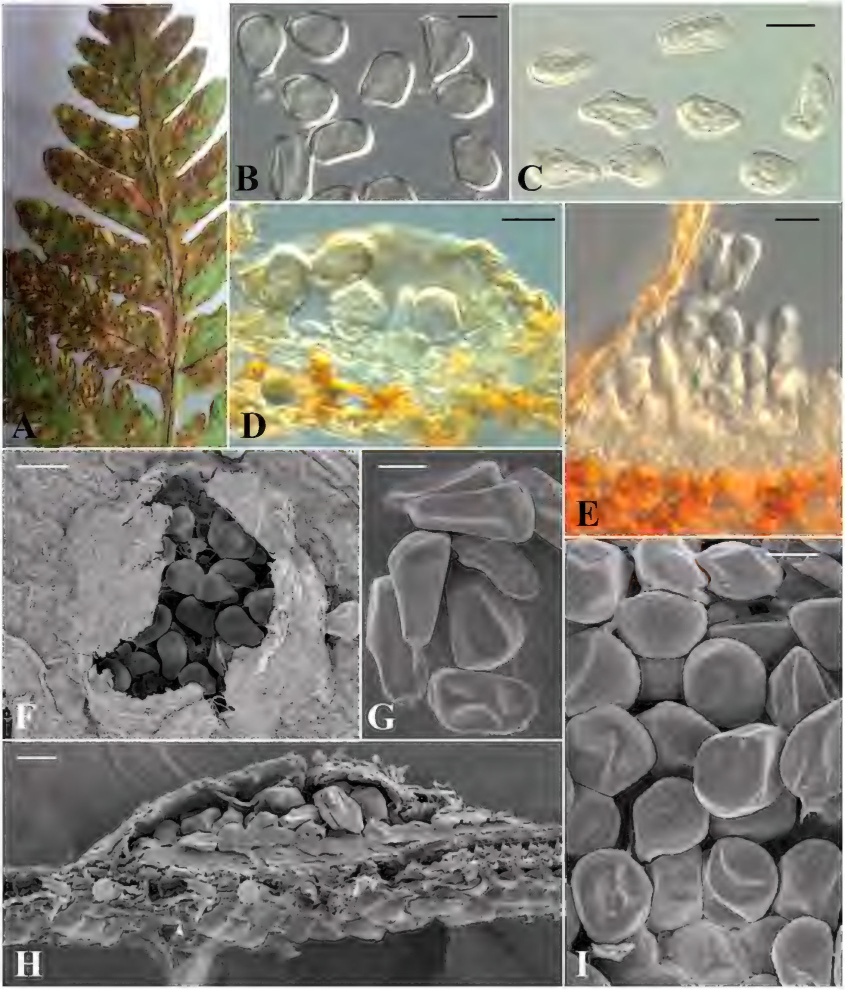

Fig. 1. *Hyalopsora aspidiotus.* A. Uredinia on lower leaf surface of *Gymnocarpium jessoense*. B. Amphispores on *G. jessoense*. C. Urediniospores on *G. disjunctum*. D. Vertical section of a sorus of amphispores on *G. jessoense*. E. Vertical section of a uredinium on *G. disjunctum*. F. Sorus of amphispores on the lower leaf surface of *G. jessoense* observed by SEM. G. Amphispores on *G. jessoense* by SEM. H. Vertical section of a uredinium on *G. disjunctum* by SEM. I. Urediniospores on *G. disjunctum* by SEM. Scale bars: B–F, H = 30 µm; G, I = 20 µm.

sometimes angular, 26.5–36 × 16.5–23 µm (av. 31.5 × 19.5 µm), walls thin, 1–1.5 µm, hyaline, smooth when observed under LM, but minutely verrucose under SEM. Amphispores abundant, subglobose, obovate, ellipsoid or oblong, sometimes angular, 37.5–56.5 × 26–40.5 µm (av. 46.5 × 34.0 µm), walls thick, 4–8 µm, hyaline, smooth. Telia not found in specimens from China.

SPECIMENS EXAMINED—CHINA:

Amphispores on ***Gymnocarpium jessoense*** (Koidz.) Koidz.: **JILIN PROVINCE**, Yanji, Changbai Mt., 42°24¢N 128°07¢E, alt. 1125 m, 22 August 014 (HMJAU8556); 22 September 2014 (HMJAU8555).

Urediniospores and amphispores on ***Gymnocarpium disjunctum*** (Rupr.) Ching: **HEBEI PROVINCE**, Xiaowutaishan Mt., 24 August 1990 (HMAS67473). **BEIJING MUNICIPALITY**, Tiansishan Mt., 17 August 1957 (HMSA55065); 22 June 1956 (HMAS55064); Baihuashan Mt., 7 June 1957 (HMAS55063); 25 June 1964 (HMAS55078).

Amphispores on ***Phegopteris connectilis*** (Michx.) Watt: **JILIN PROVINCE**, Yanji, Changbai Mt., August 1991 (HMAS67289).

HOSTS & DISTRIBUTION IN CHINA—*Gymnocarpium jessoense* (new host for China), Jilin Province; *G. disjunctum* (new host), Hebei Province, Beijing Municipality; *Phegopteris connectilis* [= *P. polypodioides*, *Doryopteris phegopteris*] (Xue & al. 1997) Jilin Province, Heilongjiang Province.

Although urediniospores and teliospores were not found, we identified the new specimens on *G. jessoense* as *H. aspidiotus* because the amphispores were morphologically identical with those described by Hiratsuka (1936), Hiratsuka & al. (1992), and Azbukina (2015). *Gymnocarpium jessoense* has been recorded as a host plant for this rust from Russian Far East (Azbukina 2015), but not previously reported from China. *Hyalopsora aspidiotus* is widespread and commonly found in Europe, North America, Russia, Korea, and Japan on *Gymnocarpium* species (Ito 1938, Hiratsuka 1958, Uchida 1964, Hiratsuka & al. 1992, Azbukina 2015, Termorshuizen & Swertz 2011). In China this rust has previously been recorded only on *Phegopteris connectilis* from Heilongjiang Province in northern China (Xue & al. 1997).

We also examined specimens deposited as *H. aspidiotus* in HMSA to confirm our identification, which also revealed *G. disjunctum* as a new host plant for *H. aspidiotus* and the rust's wider distribution in China (Beijing, Hebei, Jilin, Heilongjiang). Spermogonial and aecial stages of *H. aspidiotus*, known on *Abies* species in Europe and North America, have never been reported in Asia (Hiratsuka 1958).

Hyalopsora hakodatensis Hirats. f., Trans. Tottori Soc. Agric. Sci. 4(1): 20, 25. 1932. FIG. 2

Uredinia amphigenous, minute, subepidermal, orange to orange-yellow. Urediniospores ellipsoid, oblong or clavate, sometimes angular, 16.5–26.5 × 12.5–16.5 µm (av. 22.5 × 14.5 µm), walls thin, 0.5–1 µm, hyaline, smooth

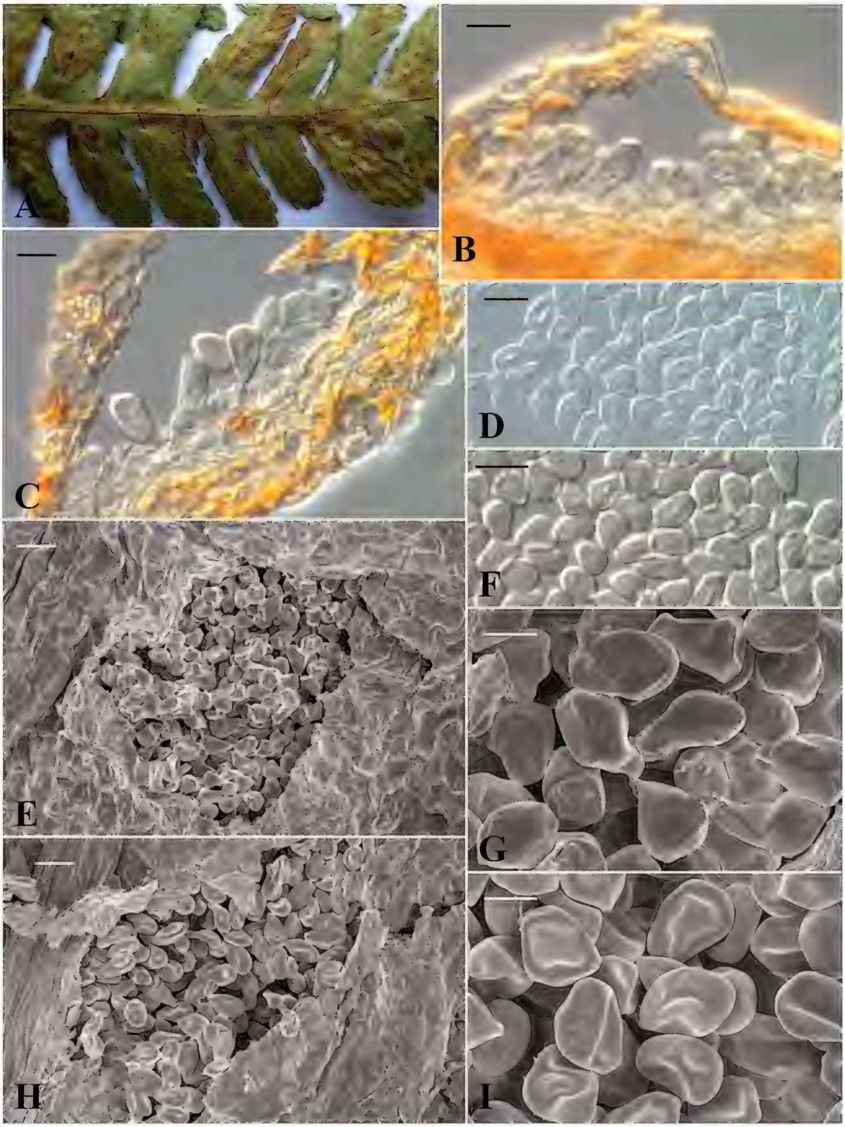

Fig. 2. *Hyalopsora hakodatensis.* A. Uredinia on lower leaf surface of *Deparia orientalis*. B. Vertical section of a uredinium on *D. orientalis*. C. Vertical section of a sorus of amphispores on *Lunathyrium* sp. D. Urediniospores on *D. orientalis*. E. Uredinium on the lower leaf surface of *D. orientalis* observed by SEM. F. Amphispores on *Lunathyrium* sp. G. Urediniospores on *D. orientalis* by SEM. H. Sorus of amphispores on *Athyrium* sp. by SEM. I. Amphispores on *Athyrium* sp. by SEM. Scale bars: B–F, H = 30 µm; G, I = 25 µm.

when observed under LM, but minutely verrucose when observed by SEM. Amphispores obovate, pyriform or oblong, sometimes angular, 20–31.5 × 15.5–21 µm (av. 25.5 × 17.5 µm), walls thick, 1.5–4 µm, hyaline, smooth. Telia not found.

Specimens examined—CHINA:

Urediniospores and amphispores on ***Deparia orientalis*** (Z.R. Wang & J.J. Chien) Nakaike: **Jilin Province**, Yanji, Changbai Mt., 42°13¢N 128°12¢E, alt. 1035 m, 23 September 2015 (HMJAU8557).

Urediniospores and amphispores on ***Dryopteris* sp.**: **Yunnan Province**, Kunming, Xishan, December 1938 (HMAS11209)

Urediniospores and amphispores on ***Phegopteris decursive-pinnata*** (H.C. Hall) Fée: **Fujian Province**, Jianyang, 18 September 1980 (HMAS41581).

Amphispores on ***Athyrium iseanum*** Rosenst.: **Yunnan Province**, Kunming, 19 October 1985 (HMAS50158).

Urediniospores and amphispores on ***Arthyrium* sp.**: **Tibet**, Nyalam, 10 October 1990 (HMAS79173).

Urediniospores and amphispores on ***Lunathyrium* sp.**: **Hainan Province**, Bawangling, 29 March 1993 (HMAS 77886).

Hosts & distribution in China—*Athyrium iseanum* [= *A. dissectifolium*] (new host), Yunnan Province; *Athyrium* sp., Tibet; *Deparia orientalis* [= *D. albosquamata*] (new host), Jilin Province; *Dryopteris* sp. (Tai 1979), Yunnan Province; *Lunathyrium* sp., Hainan Province; *Phegopteris decursive-pinnata* (new host), Fujian Province.

We identified the specimen on *D. orientalis* as *H. hakodatensis* based on its small amphispores and urediniospore characteristics that were identical with those described by Hiratsuka & Uemura (1932), Hiratsuka (1936), Hiratsuka & al. (1992), and Azbukina (2015). *Hyalopsora hakodatensis* has been reported on species of *Athyrium, Diplazium*, and *Thelypteris* from Japan, Taiwan, Korea, Russian Far East, and Nepal (Hiratsuka 1958, Uchida 1964, Hiratsuka & al. 1992, Azbukina 2015). *Deparia orientalis* is a new host plant for this rust fungus. Previously, the presence of *H. hakodatensis* in China was based solely on one specimen on *Dryopteris* sp. from Yunnan Province (Tai 1979).

Our examination of specimens deposited as *H. hakodatensis* in HMAS morphologically confirmed our identification and revealed *Athyrium iseanum* and *Phegopteris decursive-pinnata* as new host plants for *H. hakodatensis* and clarified the rust's distribution in China (Yunnan, Hainan, Fujian, Jilin, Tibet). *Hyalopsora hakodatensis,* suspected to have a wide range of fern hosts, is widely distributed in China. Spermogonial and aecial stages have not been reported, although they may be produced on species of *Abies* (Hiratsuka & al. 1992, Azbukina 2015).

Acknowledgments

This work was financed by the Fungal Flora in Jilin Province (20130206073NY). We wish to thank Dr E.H.C. McKenzie (Manaaki Whenua Landcare Research, Auckland, New Zealand) and Dr C.M. Denchev (Bulgarian Academy of Sciences, Sofia, Bulgaria) for critical reading of the manuscript and suggestions. We express our thanks to Dr A. Ebihara (Department of Botany, National Museum of Nature and Sciences, Tsukuba, Japan) for identification of ferns collected from the field in Jilin Province.

Literature cited

Azbukina ZM. 2015. Definitorum fungorum Rossiae, Ordo *Pucciniales* 1. Dalnauka, Vladivostok. [In Russian]

Cummins GB, Hiratsuka Y. 2003. Illustrated genera of rust fungi, 3rd ed. American Phytopathological Society, St Paul, Minnesota.

Hiratsuka N. 1936. A monograph of the *Pucciniastreae.* Memoirs of the Tottori Agricultural College 4. 374 p.

Hiratsuka N. 1958. Revision of taxonomy of the *Pucciniastreae.* Memoirs of the Faculty of Agriculture, Tokyo University of Education 5. 167 p.

Hiratsuka N, Uemura Y. 1932. On Japanese species of *Hyalospora*. Transactions of the Tottori Society of Agricultural Science 4(1): 11–27. [In Japanese].

Hiratsuka N, Sato S, Katsuya K, Kakishima M, Hiratsuka Y, Kaneko S, Ono Y, Sato T, Harada Y, Hiratsuka T, Nakayama K. 1992. The rust flora of Japan. Tsukuba-shuppankai, Tsukuba.

Ito S. 1938. Mycological flora of Japan, vol. 2, no 2. Yokendo, Tokyo.

Tai FL. 1979. Sylloge fungorum sinicorum. Science Press, Beijing.

Termorshuizen AJ, Swertz CA. 2011. Dutch rust fungi. Aad Termorshuizen, the Netherlands.

Uchida S. 1964. Taxonomic studies on the fern rusts in Japan. Memories of Mejiro Gakuen Woman's Junior College 1: 37–92.

Xue Y, Li Z-Y, Zhang M, Xiao X-Y. 1997. A new record species of *Hyalopsora* in China. Bulletin of Chinese Botanical Research 17: 54–55.